GUIDELINES FOR PREPARING QUALITY ASSURANCE PROJECT PLANS (QAPPS) FOR SECTION 319 PROJECTS

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Office of Water Quality
Watershed Management Section
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Preface

What is a QAPP and why do we need one?

A Quality Assurance Project Plan (QAPP) is a document that describes in detail the objectives of a project and the specific procedures that will be followed to ensure the data generated will serve those objectives. A QAPP must be submitted and approved for any project that uses Section 319 or other federal funds (including matching funds) to generate environmental data whether physical, chemical, or biological in nature. More importantly, the QAPP will provide you with a roadmap that will help you move toward the successful completion of your project objectives.

Specifically, the QAPP:

- provides focus during the planning process,
- facilitates communication among staff during project implementation,
- provides a comprehensive study plan for staff to follow helping to ensure data quality,
- allows you to discover problems with data quality before they get out of hand, and
- provides a starting point for preparing your final project report.

What is the process for getting a QAPP approved?

Data collection should not begin until the QAPP has been approved. Therefore, the contractor/grantee directly responsible for the project should submit a draft QAPP to the Watershed Management Section (WMS) of the Indiana Department of Environmental Management (IDEM) as soon as possible after receiving notification of their grant award. The WMS Quality Assurance (QA) Manager will be available to provide additional guidance and answer any questions you may have while designing your study and writing your QAPP. When you submit your QAPP, the QA Manager will review it and provide comments and suggestions for improvement. Once the necessary changes are made, the contractor will sign the title page and return the QAPP to the IDEM. The contractor will be notified of the IDEM's approval of the QAPP and will receive a copy of the title page signed by the appropriate IDEM staff as verification that the plan has been approved. *The contractor should distribute the approved plan to everyone responsible for its implementation.*

Please note that any changes to the QAPP must be submitted, in writing, to the QA Manager for review prior to implementation of the changes. The QA Manager will review the changes to determine if they will significantly impact the technical and quality objectives of the project and to ensure that the original study goals can still be achieved. If needed, the QA Manager will provide comments and suggestions for improvement. Once any necessary changes are made, the IDEM will send a letter notifying the contractor that the proposed changes have been approved.

Getting Started/How this Document is Organized

These guidelines describe the elements to be included in the QAPP for your project and reflect U.S. Environmental Protection Agency (EPA) requirements (1994). If you have already decided how you will conduct your study, these guidelines will help you to identify and address potential problems with your data collection/handling methods and/or analyses. If you are just beginning to formulate your approach to monitoring, this document will help you design a monitoring program that will achieve your project goals and a QAPP that clearly illustrates the quality of the data you will collect. The US EPA also provides guidance for use in preparing a

QAPP, which can be downloaded for viewing and printing in Adobe Acrobat format from www.epa.gov/quality/qs-docs/g5-final.pdf.

The IDEM recognizes the wide variety of approaches available to monitoring nonpoint source pollution and has designed this document to provide a general set of guidelines applicable to all types of monitoring activities undertaken for Section 319 projects. Because this document cannot address every possible approach in sufficient detail, it focuses instead on the two types of monitoring activities most commonly used for Section 319 projects – chemical and biological monitoring. Although most of the sections in this guidance contain general information applicable to both types of monitoring, the organization of this document is intended to enable projects to easily find the information relevant to the type of monitoring they are doing. As such, information specific to chemical and biological monitoring is included under separate subheadings where necessary. Information specific to the use of electronic field equipment is also included under its own subheading.

It is required that you follow the format of this guidance and address the elements of the QAPP in the order presented because many sections build on the foundation laid in earlier sections, particularly in your project description. The level of detail required in the QAPP will vary according to the nature of the work being performed and the intended use of the data. In some cases, not all sections of the QAPP may be applicable. These sections must still be included in the QAPP along with a statement explaining why they are not applicable to the project.

An outline showing all the necessary elements of the QAPP is included. This outline can also be used as a checklist to help you determine if you have included all the required information. The remaining pages provide explanation, guidance and examples of the kinds of information to be included in each section of the QAPP. Appendix A provides a glossary of terms and acronyms used in this document. Appendix B provides sample tables for various sections of the QAPP, and because many projects use Hoosier Riverwatch methods, relevant tables specific to those methods are provided in Appendix C.

Please use a document control format for your QAPP as it will make revisions much easier. Using a document control format simply involves adding a header to your document that includes the Section 319 project ARN # and the version/draft number and/or date for the document. All pages in the main QAPP document must also be numbered (page numbers on tables, figures, and/or appendices are optional).

For questions regarding QAPP requirements or for assistance in planning your study and/or preparing your QAPP, you may contact Jody Arthur, QA Manager, at 317-234-1424 or by e-mail at jarthur@dem.state.in.us.

QAPP Outline/Checklist

- ☐ Is your QAPP in a Document Control Format?
- ☐ Title Page with Section 319 project name and ARN #
- ☐ Table of Contents
  - ___Have you included all sections of the QAPP, including the distribution list?
  - ___Have you included all figures and appendices (i.e. attachments)?
  - ___Is the page numbering correct?

- ☐ Distribution List
  - ___Have you included the name of everyone who will receive a copy of the QAPP?
  - ___Have you included all key personnel involved in the implementation of your study?

- ☐ Section 1: Study Description
  - ☐ Historical Information

    ___Have you described the water quality problem you are studying?

    ___Have you included specific information about known or suspected contaminants in the system (if known) and the source of this information?

    ___Have you included relevant information from other studies, if available?

  - ☐ Study Goals

    ___Have you stated each of your study goals in a clear and concise fashion?

    ___Have you included specific information about how your data will be used including any decisions that will be made from your data and by whom?

  - ☐ Study Site

    ___Have you described the site(s) to be studied?

    ___Have you listed all the parameters to be studied?

    ___Have you attached a site map delineating the boundaries of the watershed(s) and, if applicable, the smaller area(s) within the watershed(s) that you are studying?

  - ☐ Sampling Design

    ___Have you described your sampling approach, including the type of monitoring you will do, when and how often you will sample?

    ___Have you described how this approach will meet each goal of your study?

    ___Have you clearly explained the rationale used in choosing each sampling location?

    ___Have you described what makes your sampling location(s) representative?

    ___Have you provided a summary of your methods?

  - ☐ Study Timetable

    ___Have you included a schedule for your study?

    ___Does your schedule show the start and end date for your study and all important activities related to your study?

    ___Is your schedule realistic?

    ___Have you described any potential constraints on your monitoring activities?

- ☐ Section 2: Study Organization and Responsibility
  - ___Have you included contact information for each person/party involved in the study?

___Have you clearly described the responsibilities of each person/party involved in the study?

☐ Section 3: Data Quality Objectives

☐ Precision

___Have you stated a specific precision goal for each parameter?
___Have you indicated how precision will be assessed/calculated for each parameter?

☐ Accuracy

___Have you stated a specific accuracy goal for each parameter?
___Have you indicated how accuracy will be assessed/calculated for each parameter?

☐ Completeness

___Have you stated a specific completeness goal for each parameter?
___Have you indicated how completeness will be calculated for each parameter?
___Have you described any potential problems that could occur to hamper your sample collection and analysis?
___Have you described your contingencies for these potential problems?

☐ Representativeness

___Have you explained what makes your field measurements and/or samples collected for laboratory analysis representative of the conditions you are trying to measure?
___Have you explained what makes your laboratory data representative?

☐ Comparability

___Have you summarized the purpose of your study?
___Have you summarized the parameters to be measures and the methods to be used?

☐ Section 4: Sampling Procedures

___Have you included a site map showing all sampling locations and other geographic features relevant to the study?
___Have you listed/described all of the sampling equipment to be used for each parameter and the cleaning and preparation methods for each?
___Have you listed/described each type of sample to be collected including the volume/amount needed for each analysis?
___Have you included SOPs or detailed descriptions of the collection methods for each type of sample?
___Have you described all applicable sample preservation methods?
___Have you described all applicable sample handling and storage methods?

☐ Section 5: Custody Procedures

___Have you clearly described the step-by-step procedures involved in transferring samples from field to laboratory?
___Have you described the information to be recorded on transfer documentation or attached a sample chain of custody form?

☐ Section 6: Calibration Procedures and Frequency

___Have you included all the equipment to be calibrated, including both field and/or laboratory instruments?

___Have you indicated how often each instrument will be calibrated?

___Have you described the calibration procedures or attached the calibration instructions?

☐ Section 7: Analytical Procedures

___Have you described all the analytical methods to be used in the field and/or laboratory?

___Have you described all unusual methods to be used and/or any modifications to established methods?

___Have you described any sub-sampling and/or sample preparation required for sample analysis?

___Have you indicated the performance range/detection limits associated with each method to be used?

☐ Section 8: Quality Control Procedures

___Have you described/listed every QC procedure to be employed in your study?

___Have you indicated how often you will perform each check (i.e. procedure)?

☐ Section 9: Data Reduction, Review, and Reporting

☐ Data Reduction

___Have you described your methods for converting your raw data for each parameter into results?

___Have you included relevant equations and defined all the units and terms used?

☐ Data Review

___Have you fully described the process by which your data will be checked for errors and/or omissions?

___Have you indicated which components of your data set are to be reviewed (e.g. field sheets, analysis results, etc.)?

___Have you indicated when and how often during the study data review will take place and by whom?

☐ Data Reporting

___Have you described how you will translate/present your data to your target audience?

___Have you indicated when and how often you will report your results to your target audience and your Section 319 Project Officer?

☐ Section 10: Performance and Systems Audits

___Have you indicated the types of audits you will perform and how often they will be performed?

___Have you indicated specifically what procedures/results these audits will include?

___Have you indicated which audits will be conducted internally and/or externally and by whom?

☐ Section 11: Preventative Maintenance

___Have you described the preventative maintenance procedures for all field and laboratory equipment to be used in the study?

___Have you indicated how often these procedures will be performed?

☐ Section 12: Data Quality Assessment

☐ Precision

___Have you described your procedure for determining whether or not you have met your goal(s) for precision?

___Have you described your procedures for identifying outliers in your data set?

___Have you indicated how you will determine whether outliers are accepted or rejected as valid?

___Have you described how/whether you will use your data if precision problems are detected?

☐ Accuracy

___Have you described your procedure for determining whether or not you have met your goal(s) for accuracy?

___Have you described how/whether you will use your data if accuracy problems are detected?

☐ Completeness

___Have you described your procedure for determining whether or not you have met your goals for completeness?

___Have you described what effects not meeting this goal will have on your study?

☐ Section 13: Corrective Action

___Have you described specific procedures to correct any problems with accuracy and precision that are revealed by your QC checks discussed in Sections 3 and 8?

___Have you described contingencies for any sampling constraints described in Section 3 under completeness?

☐ Section 14: Quality Assurance Reports

___Have you indicated what your QA reports to the IDEM will include and how often you will send them?

☐ References Cited

___Have you included information for every reference you cited in the text of your QAPP?

___Have you included enough information to allow someone to locate the publication in a library or on a website?

Title Page

The title page is the first required element of the QAPP (an example page follows) and should contain these elements:

- the complete title of the project and its location;
- the project's ARN (IDEM contract) number;
- the name of the organization that prepared the plan (either the grantee or other organization if hired by grantee to prepare the QAPP);
- the version number (e.g. first draft, second draft, final draft, etc.) and the date (month and year) submitted, and;
- the place for authorizing signatures of the following people:

Project manager (the person responsible for implementation of the study)
IDEM WMS QA Manager (provided on sample page)
IDEM WMS Section Chief (provided on sample page)
IDEM Planning Branch Chief (provided on sample page).

Table of Contents

A table of contents is the second required element in the QAPP (an example page follows). Provide the following information in the sequence shown along with the corresponding page numbers:

1. A distribution list of staff responsible for implementing the QAPP including contact information (mailing address, phone number, and e-mail address if available).

2. A list of the 14 required elements (sections) of the QAPP including subsections if used.

3. A list of references cited if applicable (e.g. SOPs, methods manuals, etc.)

4. A list of appendices.

5. A list of tables.

6. A list of figures.

Distribution List

Include a list of all the persons responsible for implementation of the QAPP – project managers in the field, laboratory managers, and anyone else directly involved in the study. Please include each person's name and his/her role/title relative to the study.

EXAMPLE TITLE PAGE

QUALITY ASSURANCE PROJECT PLAN

FOR

[Project Name]
[ARN ##-###]

Prepared by

[Name of grantee or other organization participating in preparation of the QAPP]

Prepared for

Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

[Draft version number]
[Month and year]

Approved by:

Project Manager: _____ _____
[Type name here] Date

WMS QA Manager: _____ _____
Jody Arthur Date

WMS Section Chief: _____ _____
Jill Reinhart Date

Planning Branch Chief: _____ _____
Mary Ellen Gray Date

EXAMPLE TABLE OF CONTENTS

TABLE OF CONTENTS

Section 1: Study Description

Historical Information

Describe the nature of the water quality issue you are studying including information regarding the sources and fate of known or suspected pollutants. Present a brief historical perspective of the area and/or situation to be studied. Include any relevant information from previous studies.

Study Goals

Provide a clear and concise statement describing your monitoring goals. These goals should outline the specific problem(s) to be studied or the question(s) to be answered and will serve as the basis for your sampling design. In determining the goal(s) of your study, be as specific as possible. Avoid vague statements – they will make designing your study more difficult. Example:

Vague → The goal of this study is to improve water quality in Bubbly Creek watershed.
Specific → The goal of this study is to determine where water quality problems exist in Bubbly Creek watershed.

While there are a variety of ways to improve water quality, it is difficult to articulate just how you will achieve the first goal by sampling. For instance, how does sampling actually improve water quality? In contrast, it is much easier to see how the second, more specific goal might be achieved with a well-planned sampling program.

How will your data be used? What decisions will be made from it?

Your study goal(s) will also help you decide how good your data need to be. For example, the data generated by a school group that uses sampling for the purposes of educating students does not necessarily need to be as precise and accurate as data collected by a watershed group trying to assess specific problems in its watershed. The data generated by both groups, while perhaps very different in terms of precision and accuracy, will be equally valid if they allow those groups to achieve their study goals. *In describing the goal(s) of your study, it is important to include information about how the data will be used and any decisions that will be made from the data collected, and by whom.*

Study Site

Describe the study site/watershed and list the parameters to be measured. Include maps or drawings with sufficient detail to correlate the study objectives with the proposed sampling plan. Individual sampling locations may be included on these maps/drawings or may be submitted on a separate map for Section 4. Also include any known or anticipated features that may have a bearing on the study such as watershed size and boundaries, best management practices (BMPs), topography, geology, accessibility, etc.

Sampling Design

For this section, you must demonstrate how you have planned your study. This is accomplished by presenting clear rationale for your decisions about where to sample, what to sample, and how often. It is often useful to view this as a series of questions:

Am I sampling in enough locations? Are they the correct locations?

All environmental monitoring is, at best, a generalization. Because it is impossible to monitor every inch of a given water body, we are forced to limit our sampling to a finite number of sites and apply our interpretations to a larger area. Thus, sampling locations should be chosen that are

representative of the conditions you are trying to measure. What is representative depends on the specific questions you are trying to answer (i.e. your study objectives).

There are basically three types of study design to consider when determining where to sample – probabilistic, synoptic and targeted. All three approaches are designed to answer different types of questions. Which you choose will depend on what you are trying to discover with your sampling.

1. A **probabilistic** study design involves a completely random selection of sample locations throughout the watershed. Random site selection means that every point in the watershed has an equal chance of being selected. This ensures that sites are representative because no single set of conditions (or site characteristic) has a higher probability of being selected unless that set of conditions is more prevalent in the watershed. Therefore, random site selection allows you to apply results obtained from a finite number of sites to the watershed as a whole. As such, this approach can provide a good assessment of the overall water quality conditions in your watershed. It should be noted that ensuring true randomness in site selection is difficult without the help of statistical computer software. A potential problem with using a probabilistic approach is that site accessibility issues may force you to move a sample location, which ultimately reduces the true randomness of your sampling design. In addition, the number of sites required to adequately characterize your watershed, which must also be determined statistically, may be higher than what is feasible given your group's time and financial resources.

2. A **synoptic** approach provides a summary of your watershed based on its principal parts, or tributaries. With this approach, sampling locations are chosen along all of the major tributaries to the main stream in the watershed and within the main stream itself. A synoptic approach will not enable you to assess the water quality in the watershed as a whole because it does not use random sampling. However, this approach can provide potentially valuable information regarding each tributary's relative contribution of nonpoint source (NPS) pollutants into the main stream and stream reach conditions. Such information is particularly useful for groups wanting to determine source areas for NPS pollution and for prioritizing areas in need of restoration. This approach also allows you more flexibility in dealing with site accessibility issues without compromising the representativeness of your sample locations. Although fewer sites are required with this approach in general, the more sites you have along each tributary and the main stream, the more information regarding specific source areas of NPS pollution within the watershed your data will provide. The number of sites you choose with this approach will ideally strike a good balance between your study goals and your available resources.

3. A third approach, commonly known as a **targeted** design, allows you to assess an individual location at a specific time. A targeted approach involves choosing sampling locations both upstream and downstream of a given location to provide a before and after view of what is happening at that particular place. This approach is valuable for measuring the success/impacts of individual watershed restoration activities or changes in land use over time. For this purpose, downstream sites would be chosen at distances appropriate to detect the full range of effects. A targeted approach is also useful in honing in on specific sources and causes of pollutants in a location that has been previously identified as being affected by these pollutants. Site selection may focus on where a specific tributary enters a main stream or upstream and downstream of a suspected source. In general, a targeted design involves far fewer sampling sites than do the probabilistic or synoptic approaches. A targeted design has

very limited use geographically compared to other approaches, allowing assessment of a specific place as opposed to the larger watershed.

Once you have chosen the approach that is best suited to your study goals, you will need to refine your sampling design by ironing out the details:

Have I chosen the right parameters to answer my questions?

Your study objectives will help you determine the most suitable type of monitoring. For example, if your objective is to gauge the overall health of a stream, biological monitoring (e.g. macroinvertebrates, fish communities, etc.) will be very useful. If your goal is to determine the types of pollutants that may be impacting the system (e.g. nutrients, pesticides, etc.), chemical monitoring might be more appropriate. A combination of both types of monitoring may be needed to gain insight into the cause and effect relationships at work in the system. Both types of monitoring are discussed in more detail below.

1) Chemical Monitoring – NPS pollution enters a stream in the runoff from rain events, snowmelt and groundwater. Water chemistry monitoring of NPS pollution parameters over time will reveal very general patterns that may correspond to seasonal rainfall. However, within these broad seasonal patterns, rainfall can vary significantly from day to day and week to week. Due to this short-term variability, water chemistry measurements provide only a "snapshot" of the water quality conditions. For example, the chemical conditions you detect the day after a heavy rain event will likely be very different than those you detect after two months with little/no rain. *For water chemistry measurements to yield useful information, they must be collected during the same season(s) and, more importantly, under similar flow conditions within those seasons.* Such data – commonly referred to as baseline data – can serve as a benchmark against which to gauge future changes in water quality during the same seasons and similar flow conditions in a stream.

To reduce natural variability in your data, be consistent in when you sample – plan to collect your data during the same season(s) and under similar flow conditions.

Understanding stream flow is critical.

Water chemistry measurements are meaningless unless viewed within the context of stream flow. Stream flow (also referred to as discharge) is the volume of water flowing in a stream per unit of time. Without an understanding of the current flow conditions in a stream, it is difficult to put the numbers you get from monitoring into perspective. For example, the impact of the same amount of a given contaminant will be much greater in a stream during low flow conditions than the impact will be during high flow conditions when there is more water available to dilute the contaminant and transport it downstream. Obtaining an accurate measure of stream flow is very time-consuming. Thus, it may be more realistic given your study's resources to use a proxy – or substitute – for stream flow. For example, you can obtain rainfall data for your sampling area from local/national weather service stations. The United States Geological Survey (USGS) has many gaging stations on streams throughout the state and may be able to provide continuous flow data for the

stream(s) you are studying. There are also simple techniques available for approximating stream flow. Any one of these options would provide a first approximation of flow necessary for interpreting your results.

All studies should include stream flow or a proxy for stream flow as a parameter. In addition to stream flow, your study may include any number of other parameters, depending on your study goals and resources. Commonly used parameters include dissolved oxygen and biochemical oxygen demand (BOD), nitrates, phosphates, pH, temperature, turbidity, and E. *coli* count.

2) Biological Monitoring – Habitat assessments (which commonly include stream flow measurements) are as important to biological studies as stream flow is to water chemistry studies. Biological data must be viewed within the context of habitat because regardless of how good water quality is in a given stream aquatic organisms (fish, macroinvertebrates, etc.) cannot thrive without suitable habitat. The diversity and abundance of aquatic communities are directly linked to habitat availability. Habitat assessments are necessary in order to determine if impairments to aquatic communities are related to degraded habitat or some other factor that is not readily discernible, or both.

Habitat assessments are necessary to correctly interpret biological monitoring results.

All biological studies should include habitat assessments. In addition to habitat assessments, your study may include a variety of other parameters, depending on your study goals and resources. These might include macroinvertebrates, fish communities, surveys of aquatic vegetation (particularly useful in lake monitoring), and mussels. Note that with biological methods, it is important to choose a level of identification (family, genus, or species) that is appropriate to your project goals. In general, the higher the level of identification (i.e. more specific), the more sensitive the parameter will be to environmental conditions. Identification above the family level usually requires a trained taxonomist, which may or may not be consistent with your study's goals and resources.

For any type of water quality monitoring, there are often many methods available to test a given parameter. The method you choose will be a function of your study objectives and your resources. Bear in mind that some methods are more/less sensitive than others. A very sensitive method will detect very small changes in the parameter being measured while a less sensitive method may only detect very large or broad-scale changes. The idea of method sensitivity can be illustrated with the use of two weight scales, one that measures weight to the nearest pound and one that measures weight to the nearest ounce. While both provide an accurate measurement of weight, one is much more sensitive to small differences than the other. Method sensitivity should be considered when choosing sampling and analytical methods for the parameters you are measuring.

In field and laboratory equipment, method sensitivity is described by its detection limits, or the range of measurements over which you can expect accurate results. In biological studies, sensitivity of the method depends on the standard level of identification (i.e. family, genus, or species) and the type of metrics you choose. A metric is how you evaluate your organism samples, which might include species diversity, abundance, and/or relative tolerance to pollution.

Remember that choosing commonly used methods and parameters will enhance the comparability of your data with that generated by other studies. A review of the literature will

provide commonly accepted parameters and established methods used in water quality monitoring, and information on method sensitivity.

How often should I sample and when?

The answers to these questions depend on the type of monitoring you plan to do and the specific parameter(s) you are testing. Many environmental indicators are affected by seasonal and temporal variations. Recall that water chemistry parameters are very sensitive to stream flow variations. You should attempt to minimize these variations by sampling during similar flow conditions. Biological indicators are affected more by seasons than short-term fluctuations in stream flow. Because of this, your sampling events should be planned during similar seasons (usually summer or fall) to obtain the greatest diversity of organisms in your sample. Generally speaking, biological monitoring requires less frequent sampling than does chemical monitoring because there is less variation from month to month in the biological conditions of a stream than in its chemical conditions.

In summary, the sampling design section of the QAPP should discuss:

- where you will sample,
- when you will sample,
- what you will sample for, and
- the rationale behind each of these decisions.

Study Timetable

To ensure the timely completion of your study, you will need to develop a realistic schedule that will allow you to accomplish all the major elements of your study within the study period. In this section of the QAPP, present a timetable for your study including the beginning and ending dates for the study and the specific activities undertaken during the study, such as sampling events, arrival of samples at the laboratory, delivery of analytical results, and completion of the final report. This information can be presented as a table or in narrative form with a description of each activity associated with your study and the month in which it will occur. It is also important to describe any constraints on the schedule such as weather, seasonal variation in stream flow or the types of organisms that might be present, or equipment operation. Your timetable should be detailed, yet flexible enough to account for unanticipated problems.

Section 2: Study Organization and Responsibility

Project organization and responsibility refers to the individuals and organizations responsible for each aspect of your study. Areas of responsibility may include project management, quality assurance, fieldwork, sample analysis, performance and systems audits (see Section 10), and/or corrective action, etc. This section of the QAPP requires a list that includes the name of each individual and/or organization involved in your study, the role(s) they play in its implementation and contact information for key personnel (i.e. addresses, phone numbers and e-mails addresses if available). Include key contact people at the IDEM. An organization chart showing lines of authority and communication is helpful here.

Section 3: Data Quality Objectives

All environmental data are only estimates of the true values of the parameters measured. These estimates are affected by natural variability in the medium being sampled (e.g. water, sediment). They are also affected by random and systematic errors that occur during sampling and analysis procedures. The latter speaks to the quality of your data – an important consideration when using it as the basis for assessments and/or planning and restoration decisions. Because of the detrimental

effect that random and systematic errors can have on your data, it is necessary to develop Data Quality Objectives (DQOs). DQOs are quantitative or qualitative statements about how good your data must be in order to achieve the goals of your study – how much error is too much error?

Data quality is described in terms of the following five elements:

1) precision
2) accuracy
3) representativeness
4) comparability
5) completeness

You will need to develop a DQO describing the level of data required by your study for each of these elements, all of which are discussed in more detail below. *If your study involves taking measurements at the site in addition to collecting samples for laboratory analyses, you must develop separate DQOs for precision and accuracy for both set of measurements (i.e. those taken in the field and those completed in the lab). However, for parameters analyzed at the laboratory, you may adopt the laboratory's DQOs for precision and accuracy.*

Are you using an outside lab? If so, you can save considerable time by requesting a copy of the laboratory's QA document.

Most laboratories will have their own quality assurance (QA) document similar to the QAPP that outlines DQOs for the various analyses they perform. Try to obtain a copy of this document from the laboratory. Then you can simply include it as an attachment and refer to it in the appropriate sections throughout the QAPP.

Whether you state your DQOs in quantitative or qualitative terms will depend on the type of data you are collecting and your study objectives. Some DQOs cannot be stated numerically while others can. When a DQO can be stated either way, your decision on how to state it should be based on your study goals. For example, your goal may be to determine where specific problems in your watershed are in order to make restoration decisions. Because this sometimes involves identifying parties/practices responsible for stream impairments – and always involves making the best possible use of limited funds – the data may need to be more defensible in a quantitative sense. On the other hand, for the purposes of educating people or characterizing the general conditions of a watershed, a qualitative statement regarding the level accuracy and precision in your data may suffice.

Developing realistic DQOs with your study goals and resources in mind is important because they define the minimum level of data quality necessary to make sound decisions from your data. DQOs also prevent you from making poor decisions based on flawed data should you fail to meet them.

For each data quality element in this section of the QAPP, you should include a brief discussion of how not meeting your DQO will affect your study goals.

Precision

Precision is a measure of the agreement between two or more measurements of the same parameter taken during a single sampling event. Assessing precision allows you to ensure that you are achieving consistent results with your field sampling and laboratory methods and can indicate natural variability for a given parameter in the system you are studying. In general, precision is assessed by the use of duplicate measurements – two or more samples taken/analyzed at the same

place at the same time (in the field and/or laboratory). In the lab, these samples are commonly referred to as duplicates. In the field (and throughout the remainder of this document), they are referred to as replicates. Split samples (i.e. a single sample divided into two) may also be used to determine precision.

For this section of the QAPP, you should state:

- the frequency at which you perform replicate analyses,
- the level of precision you require for your data to be accepted as valid, and
- how precision will be calculated (see the following equations).

Precision in Water Chemistry Measurements

If water chemistry parameters are measured directly in the field, replicates or split samples should be taken at a frequency consistent with the goals for your study. If your study requires high quality data, at least 10% of all measurements (one in every ten) should be duplicated. For studies whose objectives do not require this level of precision, replicates may be taken less frequently, perhaps 5% of all measurements (one in every 20). Studies that involve laboratories must develop DQOs for precision for both field *and* laboratory measurements. Most laboratories will run duplicate analyses on a certain percentage of the samples to assess precision in their analyses. If you have the laboratory's QA document, you can use the laboratory's DQOs for lab precision and as your own. State the types of precision checks used, the frequency at which they are performed, and the equations used in precision calculations.

For two replicates, use the RPD equation. For three or more, use the RSD equation.

If only two replicate samples are taken, precision can determined by calculating the Relative Percent Difference (RPD):

$$RPD = \frac{(C - C') \times 100\%}{(C + C')/2}$$

Where:
C = the larger of the two values
C' = the smaller of the two values

If three or more replicate measurements will be taken, precision is determined instead by calculating the Relative Standard Deviation (RSD):

$$RSD = (s/x) \times 100\%$$

Where:
s = the standard deviation of all the samples
x = the mean of all the samples
Note: Most computer spreadsheet applications have simple statistical functions that can calculate these values for you (see inset on page 17).

Calculating a mean using Microsoft Excel

Place your cursor here and click on the ***fx*** symbol in the task bar at the top of the screen. A box will appear asking you what function you wish to perform on the data. In the function category box, choose "Statistical" and in the function name box, choose "AVERAGE"

DO (ppm)
7.8
8.2
8.3
8.0
7.9
8.0

Next, a box will appear asking you to define the cells for which you want to obtain an average. Cell references may automatically appear in the box labeled "Number 1". If so, check to see that they include all of your values. If not, highlight on the spreadsheet all the cells to be averaged. Click "OK". The result is the mean (i.e. average) of the values you selected.

DO (ppm)
7.8
8.2
8.3
8.0
7.9
8.0
8.0

Calculating a standard deviation using Microsoft Excel

Place your cursor here and click on the ***fx*** symbol in the task bar at the top of the screen. A box will appear asking you what function you wish to perform on the data. In the function category box, choose "Statistical" and in the function name box, choose "STDEV"

DO (ppm)
7.8
8.2
8.3
8.0
7.9
8.0

Next, a box will appear asking you to define the cells for which you want to obtain a standard deviation. Cell references may automatically appear in the box labeled "Number 1". If so, check to see that they include all of your values. If not, highlight on the spreadsheet all the cells to be used. Click "OK". The result is the standard deviation of the values you selected.

DO (ppm)
7.8
8.2
8.3
8.0
7.9
8.0
0.2

Precision with Electronic Field Instruments

Some types of field measurements can be taken with electronic meters (e.g. pH, temperature, dissolved oxygen, etc.). The precision associated with such equipment is dependent upon proper calibration and use in the field. There are two ways to state a DQO for precision when using electronic meters:

1) You can make a qualitative statement about the precision you would expect given your calibration frequency and proper use of the equipment. For example, if you will be calibrating your meter before every use and you adhere to all manufacturer's instructions every time you use it, you can expect the highest possible precision, and/or;

2) You can make a quantitative statement about the level of precision you expect to achieve in your field measurements. In order to do this you must take duplicate readings with the meter at a given frequency (commonly 5-10% of your sampling sites). This will give you a second reading (or value) that you can plug into the RPD equation to calculate precision. If you choose to express precision numerically, state the

Duplicate measurements are necessary to assess precision with field instruments.

frequency at which you take duplicate measurements and the level of precision you plan to obtain with each parameter.

Whether you need to make a quantitative statement about the precision of data you collect with electronic meters will depend on the level of data quality your study requires. Note that if you state your goal for precision qualitatively, there is no way to actually assess whether you obtained the precision desired, which may or may not adequately serve the goals of your study. Generally speaking, it is always a good idea to routinely check the precision of field measurements taken with meters by taking duplicate measurements – such checks will reveal precision problems early on providing you the opportunity to correct them *before* they infect your data.

Precision in Biological Monitoring

Precision can be achieved in biological monitoring in a number of ways. This includes appropriate training of individuals involved in field sampling and identifications, correct and consistent use of the same sampling methods throughout the project, and the analysis of replicate samples if a quantifiable level of precision is required.

If your study objectives do not require that you state your precision numerically, a qualitative statement describing the level of training that workers receive and/or their experience levels and ensuring that the same methods are used consistently will suffice for this section of the QAPP.

If it serves your study objectives to quantify precision, you can do so in a number of ways. Habitat assessments can be duplicated and their results compared. With regard to sampling, you can have more than one person identify a single sample, which shows how consistent results are when more than person is conducting identifications. You can obtain replicates for the purposes of analyzing precision by splitting a single sample into two samples for sorting and identification, collecting replicate samples at a single site, and/or sampling duplicate stream reaches. A simple way to calculate precision is to then compare these results for the number of individuals identified, which gives you an idea of how consistent you are in your sampling methods. You can also compare the results for the number of taxa/species, which will indicate precision in the identification process. Since the methods for obtaining replicate samples will provide two replicates, you can use the RPD equation on page 14 to calculate precision. The level of precision you choose should be based on your study objectives.

In addition to a qualitative statement regarding precision, if you choose to quantify precision, include a description of how you collect replicates, the percentage of your samples for which replicates will be collected (i.e. the frequency), and the level of precision you are aiming for with the method you've chosen. Also indicate the percentage of habitat assessments that will be duplicated.

Accuracy

Accuracy is a general term that describes your confidence in how well a measured value agrees with the true value for a given parameter, which is actually based on the combination of precision and bias. For the purposes of this document, the term accuracy refers specifically to measurement accuracy, which is the degree to which your measurements are affected by systematic or random errors associated with procedures and/or analytical equipment, or by interference from other components present in the sample being analyzed. Accuracy is achieved in a variety of ways depending on your type of monitoring. These are discussed in more detail below.

For this section of the QAPP, you should state

- the measures you take to ensure accuracy in the field and/or laboratory and,
- the level of accuracy you require for your data to be accepted as valid.

Most laboratories perform accuracy checks and will have established DQOs for the various analyses they perform. If you are using a laboratory, you can simply adopt its DQOs for accuracy as your own and state them here. In addition to a qualitative statement regarding field accuracy, you should also include 3) a list of the accuracy checks performed by the lab and their frequency, and 4) the equations used in accuracy calculations.

Accuracy in Water Chemistry Measurements

Systematic and random error can occur in both the collection and analysis of samples introducing bias into your water chemistry data. Systematic error can occur through improper calibration and/or consistently incorrect use of field and laboratory equipment or procedures, or through contamination of samples. Random error is caused by inconsistent sampling and/or analytical methods.

In the field, error can be assessed using field blanks, which are samples with no reagent added. Theoretically, your results for field blanks should be zero – if not, you have error in your data. Your DQO for bias in field measurements should be stated in terms of the frequency at which you take field blanks and what you will do if you get a positive reading. Statements describing any other measures you use to ensure field accuracy are also useful here. These might include adhering to all sampling methods, sample handling requirements, preservation and holding times, and proper calibration and use of field equipment, etc.

In the laboratory, error associated with sample preparation and/or operation of the analytical equipment can be determined by equipment blanks (similar to field blanks), or by comparing the results of duplicate measurements to a check standard. A check standard is a sample of known concentration. The less these results differ, the lower the bias is in the measurements. Your DQO for bias in laboratory measurements can be stated as a percentage and calculated using the following equation:

$$\%B = \frac{(x - T) \times 100}{T}$$

Where:
x = the mean of the results of duplicate analyses of the check standard
T = the concentration of the check standard
Note: Most computer spreadsheet applications have simple statistical functions that can calculate the mean for you (see inset, page 17).

Also discuss any interferences you might encounter with the methods you are using, which might also affect accuracy. For water chemistry measurements, this might include other chemical reactions in the sample medium that skew the readings your equipment produces or contamination of the sample. Depending on the type of medium you are sampling and the parameter you are measuring, your method may not be able to detect all of the parameter that is actually present in the sample. If you suspect interferences with your methods, you may want to use spiked samples in addition to field blanks and check standards to assess accuracy. The accuracy of measurements where interference is a factor is determined

Percent bias reflects errors in measurement. Percent recovery reflects error in analysis caused by interference from other components of a sample.

DQOs for accuracy in biological monitoring must be stated qualitatively.

by comparing sample results with results from a sample that has been spiked. Spiked samples are samples to which a known amount of the parameter has been added. These samples are typically used only in the laboratory and are not recommended for field use due to the difficulties associated with handling and transporting a potential contaminant. The difference between the measurements of the unspiked and spiked samples in the lab should be very close or equal to the amount of spike added.

The percent recovery (i.e. the concentration that can be detected despite interferences) can be calculated as a percentage using the following equation:

$$\%R = \frac{(A - B) \times 100}{C}$$

Where:
A = the concentration of the spiked sample
B = the concentration of the unspiked sample
C = the actual concentration of the spike added

Accuracy with Electronic Field Instruments

As discussed above, there are many parameters that can be measured directly in the field with electronic meters. Most of these meters have built-in accuracy levels, which are typically stated as a plus-or-minus value in the manufacturer's literature. With proper calibration and use, your data quality objectives for accuracy should be the highest levels available for that particular model. Simply state those levels here. Also state that you will calibrate according to the manufacturer's instructions and indicate the frequency of your calibrations.

Accuracy in Biological Monitoring

There are two types of systematic error associated with biological monitoring. One type of systematic error can be introduced during sampling (e.g. improper sampling techniques or faulty equipment), which will affect the total number of organisms collected. Another type of systematic error can occur during sample analysis – in the picking, sorting and identification of the organisms collected – which can bias both abundance and diversity results.

It is important to note that your DQO for accuracy in sampling and identification cannot be expressed in numerical form for biological monitoring. There is no standard abundance for biological communities that you can compare your results to, therefore, you cannot calculate accuracy in sampling. Likewise, there is no standard for the diversity of organisms you will find, so you cannot calculate the accuracy of your identifications.

Because your DQOs for accuracy in biological monitoring cannot be stated numerically, they should be stated in terms of the quality control measures your project will employ during sampling and throughout the identification process. Generally speaking, the more controls you build into your project, the better accuracy you can expect to achieve. Strict adherence to established field methods ensures accuracy during the sampling process.

For the identification process, control measures might include using only properly trained identifiers, making a variety of taxonomic references (i.e. identification books) available to workers

while identifying specimens, etc. You can also maintain a voucher specimen collection that has been verified by a taxonomic expert. Voucher collections can be used to spot-check identifications to ensure accuracy and as an aid in difficult identifications.

In this section, describe any control measures you have built into your study including any accuracy checks that will be performed and by whom. Describe the level of training of those performing identifications and the level to which organisms are identified (e.g. family, genus, or species). If you will collect and maintain a voucher specimen collection, indicate how it will be used in the identification process and whether the collection will be verified by a taxonomic expert.

It is also important to discuss here any interferences you might encounter with the methods you are using. This might include excessive amounts of mud and/or detritus in the sample, difficulty in identification of young life stages or taxonomic uncertainty associated with the organisms being studied.

Completeness

Completeness is a measure of the amount of useable data actually collected compared to the amount of data originally planned. In designing your sampling program, you decided on the number of sampling sites and the sampling frequency you need in order to meet your study objectives. However, problems can occur that might prevent you from collecting all the data you planned (e.g. inclement weather, equipment malfunction, etc.) or that might invalidate some of your data (e.g. problems with accuracy, precision in the field or lab, etc.). It is important to anticipate any potential problems and develop contingencies should they occur. Describe these here.

Problems can arise with any study. Plan on collecting more data than you think you'll need to meet your study objectives if possible.

Next, you should state your DQO for completeness in terms of a percentage. Ideally, you will collect 100% of the data. However, keeping in mind the potential problems that might hamper your collection of valid data, your DQO for completeness should strike a balance between the amount of valid data you can realistically expect to obtain and the minimum amount of valid data you need to be confident in your conclusions. For example, ask yourself how confident you will be in basing your decisions on 80% of the data that you had originally planned on obtaining. Would you be comfortable basing your decisions on only 40%? Stating your DQO as a percentage is important because it gives you a quantitative way in which to judge your results. At the end of your study, you can calculate how complete your data set is before you use it to make decisions. Completeness can be calculated by using the number of valid samples you actually got versus the number you expected in the following equation, which should be included in your discussion of completeness in the QAPP:

$$\% \text{ Completeness} = \frac{(\text{number of valid measurements obtained}) \times 100}{(\text{number of measurements expected})}$$

Representativeness

Representativeness is the degree to which your data actually reflect the condition(s) you are trying to monitor. For this section of the QAPP, describe the representativeness of your field data and laboratory data, if applicable. Representativeness in field data is achieved through proper design

of your sampling program and ensuring that the sampling plan is followed and that proper techniques are used. If you have provided a detailed description of your sampling program in Section 1, a summary may be sufficient here.

Representativeness in the laboratory is ensured by using proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples. If you are using a laboratory, provide a summary of procedures used to ensure representativeness. This information is likely contained the lab's QA document. If you have included this document in your QAPP, you can simply refer to it here.

Comparability

Comparability represents the confidence with which your project data can be compared to other data sets. Comparability between data sets is achieved when similar sampling and analytical methods are used and documented. For example, data collected for the same parameter using different sampling and analytical methods may not be comparable. By the same token, data from two studies using the same methods are not comparable if they have very different goals for accuracy or precision. Thus, comparability is also dependent on having similar QA objectives at the outset.

For your data to be comparable to data from other studies, your sampling and analytical methods and DQOs must be similar.

For this section of the QAPP, describe the comparability of your data with a statement that summarizes the purpose of the study, the parameters sampled and the methods used. If you plan to combine your results with those from other studies, a careful review of the methods used and the QA objectives is necessary. Provide the results of this review here to establish that your data will indeed be comparable to that from the other studies you wish to use.

Section 4: Sampling Procedures

This section of the QAPP covers the procedures related specifically to the field sampling component of your study and what is done with samples up to the point at which they are analyzed in the laboratory (if applicable). Individual sampling sites should be described here if not covered under the Study Site discussion in Section 1. Provide a site map that includes (at minimum) each of the individual sampling sites, labels for each sampling site and all features relevant to the study, a scale and a north arrow. It is also useful to include watershed boundaries to put sampling locations in context and provide a clear view of the sampling density your study entails.

This section should include detailed, stepwise instructions for the following:

1. Sampling Equipment – List the sampling equipment to be used, and describe the preparation and cleaning methods for each. Include a list of reagents and supplies that will be needed including the type of sample containers required. Pictures of any unusual sampling equipment to be used are recommended as attachments.

2. Sample Collection – Discuss the type of samples to be collected and their medium (e.g. sediment, water, etc.), including the sample volume needed for each sample type. Also discuss the frequency at which samples will be collected and the number of each sample type to be collected. Describe in detail the collection methods for each sample type. State whether samples must be composited (i.e. mixed together) or split and the methods for doing so.

Include as attachments blank copies of any forms used to record data in the field (i.e. field sheets) and reference it in this section.

3. Preservation – If sample preservation is required, describe in detail the preservation methods and maximum sample holding times allowed from collection to extraction and/or analysis.

4. Transportation – If transporting samples from the field to a laboratory, document the procedures involved in preparing samples for transport and the transportation process and describe how samples will be stored before and after processing and/or analysis.

Attaching SOPs can save you time in preparing your QAPP.

Documents describing the standard operating procedures (SOPs) for a given method may be attached and/or referenced if they contain sufficient detail. These must be up-to-date and readily available to all staff who will use them, particularly those conducting field sampling and laboratory analyses. Any modifications to a method should be explained and described fully. If you are using very new and/or uncommon sample collection methods, you should provide a detailed description of them here. EPA-approved or other published methods (e.g. Hoosier Riverwatch), may be cited by reference.

A summary table listing the parameter and the sampling method, sampling schedule, sample type (i.e. matrix), equipment used in field measurements (including who manufactures it), sample containers, volumes, and holding times, etc. is useful here.

See Appendices B and C for example summary tables for sampling procedures.

Section 5: Custody Procedures

Custody procedures track samples that are transferred from the field to the laboratory for analysis, identification, and/or storage. If your study involves a laboratory, describe the custody procedures for any transfer of samples that will occur during your study including transfers from field to laboratory and transfers to different departments within the laboratory or to another facility for additional analyses. Attach examples of any custody sheets used to document these transfers and indicate who will maintain the custody documentation. Also indicate who will have custody of field sheets and describe how samples are to be labeled or tagged including any identification scheme that will be used.

Section 6: Calibration Procedures and Frequency

This section applies to studies using electronic field equipment and using laboratories in which analytical equipment will be used.

Calibration of Electronic Field Equipment

Describe the calibration procedures to be performed for field equipment. If properly followed, SOPs for calibration may be attached and referenced here. Also indicate the frequency of calibration checks and any conditions that will require re-calibration. For field equipment that is calibrated using a standard solution (e.g. pH meters), document where the standard was obtained, its purity, and any other relevant information.

This section is most easily accomplished by referring to the manufacturer's instructions as long as you have identified the manufacturer of your equipment. If you did not include a summary table in Section 4 that shows the field equipment to be used and its manufacturer(s), include that information here.

Calibration of Laboratory Equipment

As with field equipment, the calibration procedures must be described along with the frequency of calibration checks and conditions that will require re-calibration. For lab equipment that is calibrated using standard solutions, document where the standard was obtained, its purity, and any other relevant information. If you are using an outside laboratory for sample analysis, much of this information can be found in the laboratory's QA document, which can be referred to here if included in the QAPP as an attachment. It is useful to include a summary table in this section showing the equipment used for each parameter, its manufacturer, and calibration frequency.

Section 7: Analytical Procedures

Analytical procedures are simply the methods you will use to turn your samples into data. In this section of the QAPP, describe all the analytical procedures to be used in the field and/or laboratory. These procedures will differ depending on the type of monitoring you will do and the types of field and/or laboratory equipment you use and are discussed in more detail below.

In general, EPA-approved or published methods (e.g. Hoosier Riverwatch, IBI, etc.) may be cited by reference. However, if the method allows for any method options and/or modifications, you also need to detail the options and/or modifications you choose. If you are using very new and/or uncommon analytical methods, you should provide a detailed description of them here.

Analytical Procedures for Electronic Field Instruments

Most electronic field instruments conduct sample analysis automatically (i.e. they produce data in usable form). For analytical procedures using field instruments, you can list the name of the equipment, its manufacturer, and its units of measurement for a given parameter.

Analytical Procedures for Water Chemistry Measurements

Depending on the methods you choose your analytical procedures for water chemistry measurements can be conducted in the laboratory from samples collected in the field or directly in the field with a sample analysis kit (e.g. with a Hach kit). Describe any sub-sampling and sample preparation required for sample analysis for each parameter to be studied. Describe the instrumentation (field and/or laboratory) that will be used in sample analyses including the specific performance range for each type of equipment used.

See Appendix B for an example summary table for analytical procedures in water chemistry measurements.

The performance range of a given method is the range of measurements over which you can expect to achieve accurate results. With respect to field and laboratory instrumentation, the performance range is commonly described by its detection limits, which is the lowest concentration of a given parameter that can be reliably detected. Detection limits associated with field analytical equipment can usually be found in the manufacturer's literature. If you are using a laboratory for sample analysis, the detection limits for the equipment it uses should be available in the laboratory's QC document and can be summarized here.

In addition to stating the detection limits associated with your analytical methods/instruments, describe any other relevant performance requirements such as precision, accuracy/bias, and percent recovery (if you have presented this information in Section 3, simply refer to it here). Also discuss any interferences you might expect with the analytical methods you are using.

Analytical Procedures in Biological Monitoring

Describe the procedures involved in the identification process including any sorting and sub-sampling. For biological methods, the performance range cannot be quantified. Instead, include a discussion of the efficiency of field sorting procedures under different field/sample conditions (mud, detritus, sand, low light, etc.) and any interferences you might expect with the method (discussed under Sampling Design in Section 1).

Section 8: Quality Control Procedures

In this section, describe all the measures you take to meet the DQOs you have set for your project in Section 3. If you have already included descriptions of the quality control measures you will use in Section 3, then you can summarize them here and refer back to Section 3 for more detail.

See Appendices B and C for example summary tables showing various QC procedures.

Quality Control Procedures used in Water Chemistry Measurements

There are a number of quality control procedures that correspond to specific data quality elements discussed in Section 3. Quality control (QC) measures in the field might include the use of field replicates and split samples (to ensure precision), and field blanks (to ensure accuracy). In the laboratory, such measures might include lab duplicates, and split samples to ensure precision and reference/check standards, performance evaluation samples, and/or spiked samples to ensure accuracy. (This information should be available in the laboratory's QA document.) Method blanks may also be used to determine detection limits. A table summarizing these may be sufficient for this section, particularly if you discuss these procedures in detail in Section 3.

Other QC procedures include proper training of field staff, strict adherence to field sampling procedures and sample holding times, and proper calibration and use of analytical instruments in the field and laboratory. Discuss these here.

Quality Control Procedures used in Biological Monitoring

There are a number of quality control (QC) procedures that correspond to specific data quality elements discussed in Section 3. QC measures might include having more than one person identifying samples, splitting samples, collecting replicates, or sampling from replicate sites (all are measures to ensure precision) and having identifications verified, keeping taxonomic references readily available, and collecting/maintaining a voucher collection (these measures help to ensure accuracy). A table summarizing these may be sufficient for this section, particularly if you discuss these procedures in detail in Section 3.

QC measures can also be incorporated into habitat assessments. Due to the qualitative nature of habitat assessment methods, it is particularly useful to replicate these measurements. To do this requires that two or more people perform a habitat assessment at each site and average their resulting habitat scores. Indicate here if habitat assessments will be replicated, and describe any other QC measures you will build into your habitat assessments.

Other QC measures applicable to all types of biological monitoring include proper training of field and identification personnel, strict adherence to field sampling procedures. Discuss these here.

Section 9: Data Reduction, Review, and Reporting

Data Reduction

Data reduction refers to how you will interpret your data (i.e. convert the raw data produced during sample analysis into final results). Include in this section any statistical approaches you will use including any equations for calculations to be performed. Define the units and terms used in equations. *Please note that this does not refer to the equations used in determining precision, accuracy, and completeness. Those equations belong in Section 3.*

For water chemistry measurements, data reduction might include calculations to convert instrument readings to units of ppm or mg/L (e.g. such as those necessary with a Hach Comparator). Many portable electronic devices designed for data collection (e.g. multi-parameter devices such as a Hydrolab, or single parameter devices like pH meters, specific conductivity meters, etc.) automatically perform the calculations necessary to render the data in useable form. Measurements are read directly from the equipment making further reduction unnecessary. If using direct-read instruments, state that data reduction is not necessary.

For biological methods, describe the indices and associated metrics you will use to analyze your samples (e.g. IBI, QHEI, etc.) and any statistical approaches used.

Data Review

Data review involves checking the data for errors and/or omissions and other problems that may require investigation. Indicate the point(s) in the process at which the data will be reviewed and what the review(s) will entail. Data review may include review of field data sheets before/after leaving the field, review of bench sheets after sample analysis in the lab, and review of the entire data set before reporting the results. Also indicate who will perform the data review.

Data Reporting

Data reporting refers to how you will translate the results of your analysis into a form that your target audience can understand. This might include graphs, tables, etc. Discuss these here. Also indicate the form in which your results will be delivered to the Section 319 Project Manager at IDEM (i.e. electronic and/or hard copy).

Section 10: Performance and Systems Audits

Audits are simply check-ups to see if your study is progressing as planned. Two types of audits that can be incorporated into your study are performance and systems audits.

1. Performance audits are conducted to evaluate the quality of the data being generated. These might include audits to ensure that the sampling procedures established in Section 4 and the analytical procedures established in Section 9 are properly followed. Audits may also be conducted to ensure that the quality control procedures discussed in Sections 3 and/or 8 are conducted at the appropriate frequency.

Routine audits help to ensure that problems are detected early.

2. Systems audits are conducted to determine if the QAPP

requirements are being met. This might include performance audits of specific aspects of the study (such as those mentioned above) and/or a review of the entire study.

In general, audits may be conducted internally or externally (i.e. by an outside reviewer). The contractor/grantee in charge of overseeing the study is responsible for conducting all internal audits. The type and frequency of such audits you conduct will be determined by the needs of your study and should be described here. In general, the higher quality data you need, the more audits you should build into your study. In this section, describe the types of audits to be performed, their frequency, and indicate who will be responsible performing them. In addition to internal audits, IDEM reserves the right to conduct external audits.

Most laboratories participate in routine audits, both internal and external. If you are using a laboratory for sample analysis, it can probably provide you with an audit schedule and/or results from recent audits. This information may be contained in the laboratory's QA documents and may be cited here if that document is attached.

Section 11: Preventative Maintenance

Preventative maintenance includes all the measures taken to prevent equipment downtime, which will help you stay on schedule with your sampling and help you achieve your DQO for completeness. Describe all preventative maintenance procedures for field equipment. SOPs for preventative maintenance may be attached and cited here or the equipment manual may be cited if the manual is made readily available to field staff.

If preventative maintenance is to be performed on a regular basis, include a schedule for preventative maintenance tasks. Include a list of spare parts (such as extra batteries) and tools that are to be kept on hand, should problems arise with equipment in the field.

Laboratories are responsible for preventative maintenance of their own equipment and can usually provide you with a maintenance schedule describing the types of preventative maintenance performed and the frequency at which these are performed. Include this information here if your are using a laboratory for sample analysis. If the lab provides you with SOPs describing preventative maintenance procedures, include them as attachments and reference them in this section.

Section 12: Data Quality Assessment

Data quality assessment is the process by which you will screen your data to ensure that it is valid in terms of its precision, accuracy and completeness and that it meets your stated DQOs. Data quality assessment should include an evaluation of the following QC results:

How will you decide whether or not your data is useable?

Precision

If not described in Section 3, indicate the methods for calculating precision based on replicate results. A discussion of how you will deal with outliers in your data set is also important to this section. Outliers are data that lie far outside the range expected/revealed for the majority of the data. Outliers indicate either anomalous results (i.e. data that is accurate but not truly representative of the majority of the population) or invalid (i.e. data that is flawed due to mistakes/problems in sampling/analysis). Include a discussion of how outliers will be identified and state the criteria by which they will be accepted or rejected.

Assessment of Water Chemistry Data

For laboratory analyses, the process of determining outliers commonly involves the calculation of upper and lower control limits beyond which a data point will be considered anomalous and/or invalid. This is the criterion that the laboratory would use for accepting/rejecting the data. Data are usually not considered in the final analysis if they fall outside of the range defined by the upper and lower control limits. Information on control limits can usually be found in a laboratory's QA document for the various analyses it performs. If you are using a laboratory for sample analysis and have attached its QA document to the QAPP, you may refer to it here.

For studies that are not using a laboratory for sample analysis, the process for verifying the data may be as simple as a review of the data and investigating any obvious outliers to determine if they represent anomalous flawed data. Such an investigation may include a review of the field data sheets and/or discussions with the field and laboratory personnel involved in the sampling and analysis of that particular sample. Describe this process in detail here.

Assessment of Biological Monitoring Data

For biological monitoring, the process for verifying the data may be as simple as a review of the data and investigating any obvious outliers to determine if they represent anomalous and/or flawed data. Such an investigation may include a review of the field data sheets and/or discussions with the field and laboratory personnel involved in the sampling and analysis of that particular sample to identify potential causes for the outlier. Describe this process in detail here.

Data quality assessment also involves describing what you will do if your data quality falls short of your stated DQOs for accuracy, precision and/or completeness.

Accuracy/Bias

In this section, you will describe the effects that the results of your checks for accuracy/bias will have on the data. The descriptions you include will depend on the type of monitoring you will do and the quality control procedures you have built into your study to ensure accuracy.

Assessment of Water Chemistry Data

For water chemistry data, describe what you will do if a field blank tests positive. Positive field blanks typically indicate a problem with contamination of sampling equipment, containers and/or preservatives. It is important to state the effect a positive field blank will have on your sample results. For example, will all the data collected during that sampling event be discarded as invalid? Or will an investigation be conducted to try to determine at what point in the process that contamination occurred, indicating which data should be saved and which should be discarded?

Assessment of Biological Monitoring Data

For biological monitoring data describe what you will do if, upon verification of identifications, you find a significant problem with accuracy. For example, will you discard all of the identifications produced by the individual who identified that sample, or will you investigate more of that individual's results (i.e. additional samples) to determine the extent of the problem? If the problem is limited to one or two taxa, you may be able to recount only those taxa. If the problem is consistent throughout all indentifications, the data may need to be discarded.

Completeness

Whether conducting water chemistry monitoring, biological monitoring or both, discuss the procedure for determining whether enough data have been collected to consider the study successfully completed. If not included in Section 3, provide the equation you will use for calculating completeness. Discuss the effect that not meeting your completeness goal will have on the study's success. For example, will you still be able to use your data in a qualified manner despite its limitations or will the entire study be considered a loss?

Section 13: Corrective Action

Corrective action refers to the specific measures that will be taken to correct any problems revealed by the quality control procedures described in Sections 3 and/or 8. Describe these here.

Correcting Problems in Collecting/Analyzing Water Chemistry Data

For water chemistry measurements taken in the field, discuss the conditions that will trigger corrective measures. This might include unusually higher/lower readings than would normally be expected for a given site. Corrective actions might include replacing sample containers, checking reagents to see if they are expired, and determining if the field equipment is functioning properly by visually inspecting it for problems and/or recalibrating.

Corrective actions in the laboratory are typically triggered by QC results that are outside of control limits. For studies working with a laboratory, these criteria can usually be found in the laboratory's QA document, which can be attached to the QAPP and referenced here. Note that if problems with laboratory analyses are detected, you may decide that collecting new samples is necessary to avoid falling short of your DQO for completeness. *Re-sampling is not a corrective action, but a contingency, which should be included in Section 3 under completeness.*

Re-sampling can be costly and will not prevent a problem from recurring. Corrective measures are needed to address the problem at its source.

Correcting Problems in Collecting/Analyzing Biological Data

For biological monitoring, corrective actions might be triggered by a sample in which no organisms whatsoever are found or a significant problem with identifications. Such measures might include checking to see if sampling equipment is functioning properly by visually inspecting it to determine if it is in good repair and sampling again to see if the problem occurs. In extreme cases, retraining of field and/or laboratory personnel may be required.

Section 14: Quality Assurance Reports

Projects must submit Quality Assurance (QA) Reports to the IDEM on a regular basis to ensure that any problems arising during the sampling and analysis phases of your project are corrected in a timely manner. The frequency of QA reports should be based on the data quality needs of your study. QA reports should be submitted as part of the Section 319 Quarterly Progress Reports at the appropriate frequency, under the contract duty that applies to the QAPP. In addition, the final

project report must include a QA section summarizing the quality of the data collected within the context of study goals and data quality objectives.

QA Reports may include:

- an assessment of the data in terms of its accuracy, precision, completeness;
- results of any performance and/or system audits performed during that quarter;
- any significant quality control problems encountered and the recommended solutions;
- a discussion of whether the QA objectives are being/were met and the resulting impact on decision-making; and
- any limitations on the use of the data.

References Cited

If not using footnotes, use this section for all references cited in the text of your QAPP. In general, your citations should provide enough information to enable someone to locate the publication in a library. This will include the author(s)/editor(s), the title of the book or article, the name of the publication (if the source is an article), the edition, the volume, the year of publication, page numbers, and/or document number. The references used to create this guidance document are listed in the bibliography on the following page and provide examples of how to cite various references in the QAPP.

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Appendix A: Glossary of Terms and Acronyms

Accuracy – the degree to which a measured value agrees with the true value for a given parameter; a combination of precision and bias

Analytical procedures – the method(s) used to convert samples into data

Bias – the deviation in measured values from the true value due to random and/or systematic errors in sampling and/or analysis

Calibration – adjustments to a piece of equipment, which are based on the measurement of a check standard and are made so that subsequent measurements are not biased

Check standard – a sample of known concentration; used to determine the amount of systematic error in measurements attributable to improper use/calibration of laboratory equipment

Comparability – the extent to which data can be compared between sample locations or periods of time within a study or with data from other studies; dependent on the use of documented and similar sampling and analytical methods and quality assurance objectives

Completeness – a comparison between the number of samples necessary to meet the goals of the study compared to the number of valid samples actually collected

Corrective actions – specific actions taken to correct any problems revealed by quality control procedures

Data or Environmental data – any measurements or information that describe environmental processes, a given location, or conditions, ecological or health effects and consequences, or the performance of environmental technology. For EPA, environmental data include information collected directly from measurements, produced from models, and compiled from other sources such as databases or literature

Data quality assessment – the process(es) by which you determine whether your data meets your stated data quality objectives for precision, accuracy and completeness

Data quality objectives (DQOs) – quantitative and/or qualitative statements about the level of data quality necessary to meet the goals of the goals of the study for which the data will be collected

Data reduction – the method(s) used to convert raw data produced during sample analysis into final (i.e. interpretable) results

Data reporting – the form in which study results are presented to the target audience

Data review – the process(es) involved in checking the data for errors and/or omissions and other problems that may require investigation

Detection limit – the lowest concentration of a given parameter that can be reliably detected; applies to both field and laboratory equipment

Duplicates – two or more samples taken/analyzed at the same place at the same time; used to determine precision in laboratory measurements

Equipment blank – a "clean" sample containing none of the parameter of interest, usually consisting of de-ionized water; used to determine uncertainty due to random error introduced by analytical equipment

External audit – an audit conducted by an individual(s) from an outside organization not directly associated with the study being conducted

Field blank – a sample containing a negligible/unmeasurable amount of the parameter of interest; used to determine uncertainty due to errors in sampling and/or field measurements

IDEM – Indiana Department of Environmental Management

Interferences – other components present in the sample that can interfere with the detection and/or measurement of the parameter being measured

Internal audit – an audit conducted by an individual(s) directly associated with the study being audited

Mean – the mathematical average for a set of measurements

Measurement accuracy – the degree to which a measured value is affected by random and/or systematic error associated with procedures and/or analytical equipment, or by the interference of other components of the sample being analyzed

Medium or Sampling medium – the substance in which the parameter being measured is contained (e.g. water, sediment, etc.)

Method sensitivity – the ability of a method to reliably measure the parameter of interest

NPS – nonpoint source

Percent bias (%B) – the deviation in measured values from the true value due to systematic errors in procedures expressed as a percentage; calculated to provide an assessment of accuracy

Percent recovery (%R) – the amount of a given parameter that is measured despite interferences from other components of the sample; calculated to provide an assessment of accuracy

Performance audit – an inspection of various procedures to determine the quality of the

Performance range – range of measurements over which you can expect to achieve accurate results with a given method of measurement

Precision – the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected as close as possible in time and space

Probabilistic – a study design that involves completely random site selection; useful for assessments of overall watershed conditions

Project – all of the activities undertaken under a Section 319 grant, which may/may not include environmental monitoring activities

Quality assurance (QA) – the overall management system, which includes organization, planning, data collection, quality control, documentation, evaluation and reporting activities; provides the information needed to determine if the quality of data produced meets the requirements of the project for which it was collected.

Quality assurance project plan (QAPP) – a written document that outlines the procedures a monitoring project will use to ensure that the samples collected and analyzed, the data stored and managed, and the reports written are of high enough quality to meet the goals oaf the study

Quality assurance reports – reports submitted to the IDEM as part of the Section 319 Quarterly Progress Reports that summarize any quality assurance activities undertaken during the previous quarter and any results found

Quality control (QC) – technical activities undertaken in the field and/or laboratory to reduce error in data

Random error – error caused by inconsistent sampling and/or analytical methods

Relative percent difference (RPD) – the difference in two measurements expressed as a percentage; calculated to provide an assessment of precision

Relative standard deviation (RSD) – the standard deviation expressed as a percentage; calculated to provide an assessment of precision

Replicates – two or more samples taken/analyzed at the same place at the same time; used to determine precision in field and/or laboratory measurements

Representativeness – the extent to which a measurement actually depicts the true environmental condition or population at the time the sample was collected; necessary to realistically apply results from individual sampling locations to a larger area of interest

Split samples – a single sample divided into two samples for analysis; used to determine precision in field and/or laboratory measurements

Standard deviation – the range of variation in a set of measurements

Standard operating procedures (SOPs) – a written document that describes in detail the methods to be used in sample collection, handling, or analysis; may also be used to document data management and storage procedures

Study – the component of a Section 319 project that involves environmental monitoring

Synoptic approach – a study design in which sampling locations are chosen based on the principal parts of a watershed, usually the main stream and its tributaries; useful for determining source areas for NPS pollution and for prioritizing areas in need of restoration.

Systematic error – error due to improper calibration and/or consistently incorrect use of field and laboratory equipment or procedures, or contamination of samples

Systems audit – an audit to determine if QAPP requirements are being met; may be conducted internally or externally

Targeted approach – a study design in which sampling locations are chosen both upstream and downstream of a given location; useful for measuring the success/impacts of individual watershed restoration activities or changes in land use over time

US EPA or EPA – United States Environmental Protection Agency

WMS – Watershed Management Section at the IDEM

Appendix B: Example Tables for Use in the QAPP

This appendix includes example tables for data quality objectives, sampling procedures, analytical procedures, quality control procedures and data reduction methods. Most examples provide separate tables for chemical monitoring and biological monitoring to make it easier to find information relevant to the specific type of monitoring your study will undertake. For studies involving both types of monitoring, information can be combined into one table if desired.

Please Note: These tables are provided as examples of how information might be more easily summarized in the QAPP. They are not required, nor is the information included in them intended as recommendations for your particular study.

Data Quality Objectives for Water Chemistry Measurements

Parameter	Precision	Accuracy	Completeness (%)
Flow			
Temperature			
pH			
Dissolved Oxygen			
Conductivity			
Ammonia			
Nitrate			
Phosphate			
Total Phosphorous			
Turbidity			
Total Suspended Solids			
E. *coli*			

Data Quality Objectives for Biological Measurements

Parameter	Precision	Completeness (%)
Habitat Analysis		
Macroinvertebrates		
Fish Community		
Periphyton		

Completeness objectives should be stated as a percentage, while precision and accuracy objectives may be stated numerically as a plus-or-minus value or qualitatively, depending on the specific requirements of your project. Accuracy is not included in the DQO table for biological methods because accuracy in sampling and identification cannot be quantified. For biological monitoring, a qualitative statement regarding accuracy in sampling, identification and habitat assessments is required for Section 3 of the QAPP (see pages 18-19 in the guidelines).

Please note: The parameters shown in these tables are provided as examples only. They are not all-inclusive and are not intended as recommendations for your particular study.

Sampling Procedures for Water Chemistry Parameters

Parameter	Sample Matrix	Sampling Frequency	Method (cite source and/or describe equipment)	Sampling Containers	Sample Volume	Sample Holding Time
Flow						
Temperature						
pH						
Dissolved Oxygen						
Conductivity						
Ammonia						
Nitrate						
Phosphate						
Total Phosphorous						
Turbidity						
Total Suspended Solids						
E. *coli*						

Sampling Procedures for Biological Parameters

Parameter	Sampling Season	Sampling Frequency	Method (cite source and/or describe equipment)
Habitat Analysis			
Macroinvertebrates			
Periphyton			
Fish Community			

Please note: The parameters shown in these tables are provided as examples only. They are not all-inclusive and are not intended as recommendations for your particular study.

Analytical Procedures for Water Chemistry Parameters

Parameter	Test Methods (cite method source and/or equipment)	Performance Range or Detection Limits	Units
Flow			
Temperature			
pH			
Dissolved Oxygen			
Conductivity			
Ammonia			
Nitrate			
Phosphate			
Total Phosphorous			
Turbidity			
Total Suspended Solids			
E. *coli*			

Please note: The parameters shown in this table are provided as examples only. They are not all-inclusive and are not intended as recommendations for your particular study.

Quality Control Procedures Used in Obtaining Water Chemistry Data

QC Checks	Field (yes/no)	Lab (yes/no)	Frequency
field replicates		N/A	
field equipment calibration		N/A	
field blanks		N/A	
lab duplicates	N/A		
reference/check standards	N/A		
control samples			
spiked samples	N/A*		
equipment blanks			
calibration curves	N/A		

*Spiked samples are not recommended for field use due to the difficulties associated with handling and transporting a potential contaminant.

Quality Control Procedures Used in Obtaining Biological Data

QC Checks	Field (yes/no)	Lab (yes/no)	Frequency
multiple taxonomists identiying a single sample			
splitting the sample for sorting, indentification and enumeration			
collecting replicate samples within a single site		N/A	
collecting samples from duplicate (i.e. identical) stream reaches		N/A	
collecting/maintaining taxonomic reference (i.e. voucher) samples			
"spiked" organism samples			
confirmation of identification by taxonomic expert			

Please note: The QC measures shown in these tables are provided as examples only. They are not all-inclusive and are not intended as recommendations for your particular study. The specific QC measures you select should be chosen to ensure that you can achieve your project's DQOs.

Data Reduction for Water Chemistry Data

Parameter	Unit of Measurement (raw data)	Conversions/Equation(s) used to Obtain Results

Note: Some types of field equipment and laboratory instrumentation provide a direct reading that does not need further conversion or calculation. This should be indicated in the third column.

Data Reduction for Biological Data

Parameter	Metrics	Index/Statistical Approach Used to Obtain Results

Appendix C: Example Tables for Hoosier Riverwatch Method

This appendix includes example tables for data quality objectives, sampling procedures, and quality control procedures. Separate tables for both the GREEN kits and HACH kits used by the Hoosier Riverwatch program are provided to make it easier to find information relevant to the specific type of monitoring your study will involve.

Please Note: These tables are provided as examples of how information might be more easily summarized in the QAPP. They are not required nor is the information included in them intended as recommendations for your particular study.

Data Quality Objectives for Water Chemistry Parameters -- GREEN Kit

Parameter	Completeness	Precision	Accuracy[1]	Measurement Range
Coliform Bacteria			High[2]	> or < 200 colonies/100 ml
Dissolved Oxygen			+/- 4 ppm	0-8 ppm
BOD_5			+/- 2 ppm	0-8 ppm
pH			+/- 1 pH unit	4-11 pH units
Orthophosphates			+/- 2 ppm	0-4 ppm
Nitrates			+/- 20 ppm	0-40 ppm
Turbidity			+/- 20 NTU (JTU)	0-100 NTU (JTU)
Temperature Change			+/- 1 degree	N/A

[1]The GREEN method requires participants to match water sample water w/added reagent to a color chart.

[2]Accuracy of E. *coli* counts are expected to be high given that results are reported as > or < 200 colonies/100ml.

Note that accuracy in results obtained using color charts vary according to individual color perception. Accuracy with this method may be enhanced in two ways:

1) Hoosier Riverwatch modifications to the GREEN method allows participants to estimate between incremental values shown on color charts and to report measurements as ranges rather than individual values. This modification can enhance the accuracy somewhat, because it allows more flexibility in a reading that is obviously between two values on the color chart. However, the accuracy levels shown in the table are the highest that can be documented for the GREEN method. If you will be enhancing the accuracy of your measurements by recording your results as a range instead of a single value, note this in Section 3 of the QAPP.

2) While typically used for the purposes of quantifying precision, replicates taken with this method can be averaged to obtain more accurate results and to identify obvious outliers. Note that If replicates are taken and averaged for the purposes of enhancing accuracy, one or more additional sets of averaged readings will still be necessary for the purposes of quantifying precision depending on which calculation you use (i.e. RPD or RSD). If you will be enhancing the accuracy of your data by averaging replicate measurements into a single value, note this in Section 3 of the QAPP. Indicate also that these replicates are in addition to any taken for the purposes of quantifying precision.

Data Quality Objectives for Water Chemistry Parameters -- HACH Kit

Parameter	Completeness	Precision	Accuracy[1]	Measurement Range
Fecal Coliform/E. *coli*			High[1]	> or < 200 colonies/100 ml
Dissolved Oxygen (high range test)			+/- 1 mg/L	0-17 mg/L
Dissolved Oxygen (low range test)			+/- 0.02 mg/L	0.2-0.4 mg/L
BOD_5 (high range test)			+/- 1 mg/L	0-17 mg/L
BOD_5 (low range test)			+/- 0.02 mg/L	0.2-0.4 mg/L
pH			+/- 0.2 pH units	0-14 pH units
Total Phosphate (low range test)			+/- 10%	0-1 mg/L
Total Phosphate (medium range test)			+/- 10%	0-5 mg/L
Total Phosphate (high range test)			+/- 10%	0-50 mg/L
Orthophosphate (low range test)			+/- 10%	0-1 mg/L
Orthophosphate (medium range test)			+/- 10%	0-5 mg/L
Orthophosphate (high range test)			+/- 10%	0-50 mg/L
Nitrates (low range test)			+/- 10%	0-1 mg/L
Nitrates (medium range test)			+/- 10%	0-10 mg/L
Nitrates (high range test)			+/- 10%	0-50 mg/L
Turbidity			+/- 10 NTU (+/- 10 JTU)	0 - ≥100 NTU (JTU)
Total Solids[2]			+/- 0.0001 g	
Temperature Change[2]			+/- 1 degree	

[1]Accuracies reported as percentages are for parameters measured with the HACH colorimeter and, according to the manufacturer, are typical of accuracies achieved with this device. Accuracy of E. *coli* counts are expected to be high given that results are reported as > or < 200 colonies/100ml.

[2]The measurement range for Total Solids depends on the analytical scale you will use (consult the manufacturer's literature). For Temperature Change, state the range of the thermometer used and indicate the units of measurement (i.e. Celsius or Farenheit).

Note that accuracy in colorimeter results vary according to individual color perception. Replicate values may be averaged to obtain more accurate results and to identify obvious outliers. If replicates are averaged to ensure accuracy, at least one additional set of averaged readings will be necessary for the purposes of calculating precision (i.e. RPD or RSD). Indicate in Section 3 of the QAPP if individual measurements will be taken or if, for the purposes of enhancing the accuracy of your data, two or more measurements will be taken instead and averaged into one result.

Data Quality Objectives for Biological Measurements

Parameter	Precision	Completeness (%)
Macroinvertebrates		
Habitat Assessments		

General comments regarding example DQO tables for Hoosier Riverwatch Methods:

● For all methods (i.e. GREEN, HACH, and biological methods), completeness objectives should be stated as a percentage, while precision objectives may be stated numerically as a plus-or-minus value or qualitatively, depending on the specific requirements of your project. Accuracy is not included in the DQO table for biological methods because accuracy in sampling and identification cannot be quantified. For biological monitoring, a qualitative statement regarding accuracy in sampling, identification and habitat assessments is required for Section 3 of the QAPP (see pages 18-19 in the guidelines).

● If you are using the Hoosier Riverwatch 3 Star Quality Assurance Guide to rate the quality of your chemical and/or biological data, state this in Section 3 of the QAPP and indicate the highest rating that applies. Include a reference to the Hoosier Riverwatch manual you are using.

Please note: The DQOs shown in these tables represent the highest levels of data quality that can be expected using the sampling kits provided by the Hoosier Riverwatch program and are not intended as recommendations for your particular study.

Sampling Procedures for Water Chemistry Parameters -- GREEN Kit

Parameter	Sample Volume	Sampling Frequency	Methods
Coliform Bacteria	10 ml		LaMotte GREEN Kit, Code 5880
Dissolved Oxygen	<10 ml		LaMotte GREEN Kit, Code 5889
pH	10 ml		LaMotte GREEN Kit, Code 5890
BOD_5	<10 ml		LaMotte GREEN Kit, Code 5889
Orthophosphates	5 ml		LaMotte GREEN Kit, Code 5892
Nitrates	5 ml		LaMotte GREEN Kit, Code 5891
Turbidity	<50 ml		LaMotte GREEN Kit, Code 5887
Temperature Change	N/A		Thermometer

In addition to using the table above, include in Section 4 of the QAPP a reference to the Hoosier Riverwatch Manual's section entitled *Standard Chemical (GREEN) Testing Instructions* for specific sampling procedures. Be sure to indicate the publication date located on the back cover of the manual.

Please note: The parameters shown in the table is a comprehensive list that includes all parameters covered in the Hoosier Riverwatch manual for the kits provided and are not intended as recommendations for your particular study.

Sampling Procedures for Water Chemistry Parameters -- HACH Kit

Parameter	Sample Volume	Sampling Frequency	Method/Test
Fecal Coliform/E. *coli*	1-5 ml		Micrology Laboratories Coliscan Easygel
Dissolved Oxygen (high range test)	60 ml		HACH DO Test Kit, Model OX-2P
Dissolved Oxygen (low range test)[1]	60 ml		HACH DO Test Kit, Model OX-2P
BOD_5 (high range test)	60 ml		HACH DO Test Kit, Model OX-2P
BOD_5 (low range test)[1]	60 ml		HACH DO Test Kit, Model OX-2P
pH	N/A		HACH portable pH meter, Model Pocket Pal Tester
Total Phosphate	20 ml		HACH Total Phosphate Test Kit, Model PO-24
Orthophosphate (low range test)	20 ml		HACH Total Phosphate Test Kit, Model PO-24
Orthophosphate (medium range test)[2]	20 ml		HACH Total Phosphate Test Kit, Model PO-24
Orthophosphate (high range test)	0.5 ml		HACH Total Phosphate Test Kit, Model PO-24
Ammonia Nitrogen	5.0 ml		HACH Ammonia Nitrate, Catalog nos. 2395266, 2395466
Nitrates (low range test)	5.0 ml		HACH Nitrate Test Kit, Model NI-14
Nitrates (medium range test)[3]	0.5 ml		HACH Nitrate Test Kit, Model NI-14
Nitrates (high range test)	5.0 ml		HACH Nitrate Test Kit, Model NI-11
Turbidity	~3 gallons[4]		Hoosier Riverwatch Turbidity Tube
Total Solids	100 ml		Hoosier Riverwatch
Temperature Change	N/A		Thermometer

[1]If high range test results are $\leq$ 3 mg/L, the low range test is conducted using 30 ml of prepared sample left over from high range test.

[2]If low range test results are > 1 mg/L, the medium range test is conducted using 5 ml of prepared sample left over from low range test.

[3]If low range test results are > 1 mg/L, the medium range test is conducted using 0.5 ml of prepared sample left over from low range test.

[4]Volume of water needed for turbidity test allows for spill over when pouring into turbidity tube.

In addition to using the table above, include in Section 4 of the QAPP a reference to the Hoosier Riverwatch Manual's section entitled *Advanced Chemical Testing Instructions* for specific sampling procedures. Be sure to indicate the publication date located on the back cover of the manual.

Please note: The parameters shown in the table is a comprehensive list that includes all parameters covered in the Hoosier Riverwatch manual for the kits provided and are not intended as recommendations for your particular study.

Quality Control Procedures for Biological Data

QC Checks	Yes/No	Frequency
replicate habitat assessments		
split samples		
spot checks for accuracy in identifications		
inspection of field sampling equipment		

Quality Control Procedures for Water Chemistry Data

QC Checks	Yes/No	Frequency
field replicates		
field blanks		
split samples		
calibration w/standards		
checking expiration dates on standards/reagents		

In addition to the QC procedures listed in the tables, the QA/QC section of the Hoosier Riverwatch manual provides other measures that can improve the quality of your data. In Section 8 of the QAPP, describe any quality control measures that are not included in the table.

Please note: The QC measures shown in these tables are provided as examples of measures that are compatible with Hoosier Riverwatch methods and which can be incorporated into your study to enhance the quality of your data. They are not all-inclusive and are not intended as recommendations for your particular study. The specific QC measures you select should be chosen to ensure that you can achieve your project's DQOs.